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ABSTRACT

This paper analyzes the process of collaborative research at Harvard University's Educational Technology Center, focusing on the conflicts or tensions that reveal differences in the cultures of schools and universities. It clarifies differences between schools and universities in tacit assumptions and values, in customary language and norms, and in organizational structures. The introduction discusses the current need for collaboration in research on effective instructional methods and materials to effectively prepare students for a rapidly changing, information-based society. Following this, a background section discusses the Educational Technology Center's mission and approach. It also outlines the methods employed in the collaborative research process. Next, exemplary vignettes are presented to illustrate the stages in the collaborative research process: defining targets of difficulty, diagnosis of the root of the difficulty, designing and pilot testing interventions, designing and conducting teaching experiments in classrooms, and analyzing and reporting research results. The subsequent discussion focuses on themes that emerge from these vignettes about collaborative research: maps of the subject matter domain; the nature of basic and applied research; the nature of knowledge, teaching, and learning; time considerations; and ownership and responsibility. The paper concludes with recommendations for sustained commitment, reciprocal exchanges, mutual education, and rewards for collaboration. A bibliography is included. (TE)

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Martha Stone Wiske

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A CULTURAL PERSPECTIVE ON SCHOOL-UNIVERSITY COLLABORATIVE RESEARCH

> The university stands--or should stand--behind enquiry in school as the curator of that uncertainty without which the transmission of knowledge becomes a virtuoso performance in gentling the masses. We do not live up to our principles, of course, but it is of the first importance that we do not rest from trying to do so, routinely from day to day. Whenever we assert and bully with our authority instead of reasoning on an equal base with those we teach and helping them to liberate themselves from our authority as the source of truth, we invite them to faith rather than knowledge.
>
> Lawrence Stenhouse as quoted by Rudduck & Hopkins, (1985), p.122.

I. INTRODUCTION

The transition from an industrial society to an information society requires major changes in the educational system. To prepare citizens for work in factories schools tended to operate like assembly lines, batch processing whole classes of students through the three R's. To prepare students to reason, learn, and cope with an age of burgeoning information, the goals, instructional activities, and organizational structures of schools must change (Anderson & Cox, 1987). Goals shift from transmission of knowledge to inculcation of the skill and will to gather and interpret information, critique and invent knowledge, and apply wisdom to defining and working on practical problems. Instruction shifts from recitation of facts and formulas to a process of guided inquiry in support of active learning. Students must be helped to construct their own understandings, to collaborate in creating and critiquing ideas, to connect what they learn at school to their world outside of school. School organizational structures cannot remain rigid, hierarchical bureaucracies with strict boundaries between grades, departments, and levels, and between school and community. Referring to the "twilight of hierarchy", Harlan Cleveland (1985, p. 41) asserts that in an information-rich society, "Collegial not command structures became the natural basis for organization." Schools must become communities that foster a continuous, collaborative culture of inquiry as part of their renewal process (Goodlad, 1987).

Such sweeping change within schools requires changes and collaboration throughout the educational system (Anderson & Cox, 1987; Gross, 1988; Sirotnik & Goodlad, 1988). The fickle romance between schools and universities must be permanently rekindled if the educational system as a whole is to prepare citizens for productive participation in a society dominated by mushrooming information. "Higher" and "lower" educational institutions must combine forces

in defining educational goals, developing instructional technologies, and preparing educators to accomplish their increasingly complex purposes.

One crucial arena for collaboration among schools and universities is research on effective instructional methods and materials (Lieberman, 1986). Failure to work together hampers the efforts of both institutions while precluding coherence and synergism necessary for major reform. University-based researchers working apart from the schools run the risk of producing findings that are irrelevant, inaccurate, or impractical for school people. One teacher succinctly characterized the infamous gap between educational research and practice, "You people are trying to solve a problem we don't have." Meanwhile, school people cut off from scholarly research lose the opportunity not only to contribute their wisdom to this endeavor, but also to reflect on their practice which in itself can be professionally rejuvenating.

While the general need for better collaboration between schools and universities may be recognized, and the particular benefits of collaborative research may be apparent, to behave accordingly is difficult. Prior efforts to connect people from different levels of education in joint projects have revealed many tensions between these partners who, at first glance, seem likely to be drawn by common interests. Attempts at collaborative curriculum planning and development, from Charles Eliot's Committee of Ten to the post-Sputnik reform efforts of the 1960's, have often left school people complaining of the professors' insensitivity to their needs and disrespect for their expertise (Clark, 1988). For their part, professors frequently emerge from such projects decrying the conservative, anti-intellectual culture of schools that blunts the practical success of well-designed reforms. The mutual charges of irrelevancy and disrespect seem particularly strident between members of prestigious, research-oriented universities and of schools where pressures to educate a large, diverse population of students are incessant. Goodlad (1988) concludes that schools and universities "differ in purpose, function, structure, clientele, reward systems, rules and regulations, ambience, ethos; schools and universities are markedly different cultural entities" (p. 11).

If the reforms we seek depend upon effective school-university collaboration, we must better understand these cultural differences and ways they can be productively managed. This paper analyzes the process of collaborative research at the Educational Technology Center, focusing on the conflicts or tensions that reveal differences in the cultures of schools and universities. Clarifying differences between schools and universities in tacit assumptions and values, in customary language and norms, in organizational structures, may help to chart the stormy seas that people from these settings must cross together if they are to join forces effectively. Recognizing such differences may help prevent misunderstandings that sap time, patience, and good will, precious resources no inter-organizational collaboration can afford to

waste. Clarifying the kinds of contributions that different participants can make to collaborative educational research may pave the way for greater appreciation and inclusion of complementary kinds of wisdom and expertise in educational research.

II. BACKGROUND

A. The Educational Technology Center's Mission and Approach

The Educational Technology Center was established by the U.S. Department of Education as one of its national research centers in the fall of 1983. Its mission was to "find ways of using computer and other information technologies to teach science, mathematics, and computing more effectively" (Educational Technology Center, March, 1984). In short, its aim was to conduct research to improve practice.

This goal must be distinguished from related endeavors such as curriculum development, teacher education, and client-centered school development. ETC's work ultimately included activities that might be recognized under these other rubrics, but they were undertaken in the service of the Center's research agenda. Some observers, frequently members of ETC's collaborating school districts, wished the Center provided such services directly to schools. Their preferences, combined perhaps with hopes raised by ETC's efforts to bend its research toward practical ends, sometimes led them to lose sight of the Center's prime objective and responsibility. Clarification and reiteration of ETC's research goals became an important component of the collaborative process.

The Center's architects realized that its mission required the combined expertise of a range of participants: subject matter specialists, cognitive psychologists, experienced teachers and curriculum developers, technology experts, and supporters of school-university collaboration. Accordingly they formed ETC as a consortium, based at Harvard University's Graduate School of Education, including Children's Television Workshop, the Education Collaborative for Greater Boston, Education Development Center, Educational Testing Service, Interactive Training Systems, WGBH Educational Foundation, and the public school systems of four Massachusetts communities: Cambridge, Newton, Ware, and Watertown.

Members from these various organizations were brought together at two levels. At one level, a key administrator from each consortium organization joined the administrative team from ETC to form an Agenda Group, whose purpose was to define, refine, and monitor the Center's overall research agenda. The Agenda Group included the superintendent of each participating school system and the director of the relevant unit within each of the other

consortium members. A second level of connection involved representatives from the consortium organizations who took on responsibility for ETC's day-to-day work. These connections began with the formation of three large committees--one each in science, mathematics, and computing--to specify research projects in each of these domains. Recognizing that ETC's agenda could not address all of the K-12 curriculum in these three areas, the Center's directors asked each committee to identify a limited number of "targets of difficulty". These were to be particular topics that met several criteria:

- they were widely recognized by teachers as perennially difficult topics to teach and to learn
- they involved central concepts in the discipline which students must understand in order to lay a firm foundation for further study of the subject
- they played a central part in the school curriculum
- they appeared likely to be made easier with new technologies
- at least some university people and some school people on the committee were interested in participating in research on the topic.

The committees met in the Fall of 1983, each including several university-based and school-based members, as well as people assigned to facilitate the collaborative process. The facilitators included two staff members from the Education Collaborative for Greater Boston (EdCo), a non-profit agency serving some 20 school systems in the area, and the author who was the ETC Assistant Director and its school liaison. The first task of these committees was to nominate targets of difficulty. Over a series of meetings, the nominations were debated and eventually narrowed down as members argued for and against candidate topics. In the science group, for example, after several lively meetings, the group decided to vote. Next to each topic a university person's vote was registered as 0 and a school person's vote as X. At the end of the process the three topics which had attracted a combination of Xs and Ox were selected as the ones to study. Finally, the three committees chose a total of about a dozen particular topics. They subdivided into collaborative research groups, each including from 1-4 teachers, one or more university-based researchers, and sometimes software or curriculum developers.

Each Working Group was then asked to develop a detailed research agenda. The actual writing of this document was undertaken by an academic member of each Group, who subsequently became known as the Project Leader. By Spring of 1984, once these research agendas were reviewed by the Agenda Group and approved by the Center directors, most Project Leaders hired research assistants to help carry out their Group's research. In most cases the research assistants were graduate students from Harvard or the home university of the Project Leader.

Usually Project Leaders devoted 15-25% of their time to the project, research assistants worked from 25-100% time, and teachers were expected to devote approximately 1 1/2 days per month or 5-10% time to the project. [All participants were paid for their ETC work.] Teachers were encouraged to devote more time to the project if they wished, but few were able to do so. Given full-time jobs at school, along with other professional and personal obligations, few teachers could commit more than a few days per month to ETC work during the school year. The author attended most Working Group meetings, as did a staff member from EdCo, in order to promote effective communication between school-based and university-based members.

B. Methods

Much of the information and insight reported here was gathered through participating in and observing the collaborative research process at ETC over five years. The author attended most Working Group meetings especially during the first year, as well as many other formal and informal meetings devoted to overall management of ETC. Minutes of these meetings, prepared and circulated at the time, served as one source of information for this paper. At intervals throughout the project meetings, interviews, and less formal conversations were conducted with participants in ETC collaborative research groups to discuss their experiences with this process. Some of these investigations were reported earlier by McDonald (1986).

Near the end of ETC's five-year project a series of meetings were convened with groups representing the range of participants in ETC Working Groups, to review their experience with collaborative research. Three meetings were led by an EdCo staff person whose leadership skills and neutral organizational affiliation enabled her to stimulate an honest and open sharing of sometimes painful views. One meeting included school people who represented different school systems, had participated in the entire range of Working Groups, and had joined ETC at various times during its four-and-a-half year history. The second group included research assistants whose tenure and participation in Working Groups was similarly varied. The third included Project Leaders. The agenda at each of these meetings was similar. People were asked to look back on their experiences, clarifying their initial expectations about the roles that participants would play in the collaborative research process, the ways in which collaboration was accomplished, and the conflicts that emerged. They were asked what insights they had developed about the ingredients of effective collaboration and the recommendations they would make for structuring future collaborative research projects.

Several people with particular responsibility for facilitating collaboration at ETC attended all three meetings and met afterwards to review themes that emerged.

These discussions, along with the transcribed audio tapes made at each of the meetings, have been a rich source of information for this paper. The paper corresponds in structure to the agenda of these meetings. The next section describes the phases of work undertaken by ETC Working Groups, illustrated with vignettes which focus on episodes where conflicts arose. In the next section these tensions are analyzed as reflections of cultural differences between schools and universities. Finally, in light of this analysis and building on the recommendations made by ETC participants, suggestions are offered of ways to structure effective collaborative research.

Initials are used throughout to refer to individual people. This format is intended to provide some measure of anonymity and to downplay the importance of particular people. While individual characters may strongly shape collaborative ventures, the aim of this paper is to focus on the influence of organizational cultures and structures over collaborative research efforts.

III. PROCESS OF COLLABORATIVE RESEARCH--A CHRONICLE

All ETC Working Groups faced basically the same assignment--identify a "target of difficulty" and then study ways of using new technologies to improve teaching and learning of this particular topic. Looking across their life histories, one discerns that they all undertook a roughly similar strategy. First they defined the target of difficulty, then they diagnosed its root causes (i.e. the reasons it is hard to teach and to learn), reviewed existing teaching strategies and materials, designed and developed interventions to improve the teaching and learning of the topic, tried these out in clinical research settings, and then proceeded to revise them for whole-class teaching experiments. At intervals along the way they analyzed the results of their work and published reports. Individual projects varied significantly in the depth of attention they paid to each step and in the pace of their progress through this sequence of activities. This progression is typical enough, however, to structure examination of the collaborative research process.

A. Define targets of difficulty

The first step was to define a target of difficulty which met the rather stringent and complex criteria mentioned earlier. In some Working Groups, the school people and the academics seemed rather easily to circumscribe a topic they all agreed was worth addressing. In others, this stage was more complicated.

The Heat and Temperature Group, for instance, settled promptly into agreement that students confuse these two concepts. The two ideas must be distinguished if students are to proceed to understand energy transfer. The academic on the group invited a colleague to join whose research focused on the history of scientific thinking about this topic and the applicability of this history to understanding the development of students' thinking. The group was also joined by a developer who had designed Microcomputer Based Laboratory equipment. This technology helps students deliver calibrated "dollops" of heat to a substance, accurately measure the resultant changes in temperature, and display them graphically as a function of time. The early stages of defining and diagnosing a target of difficulty and developing a technology-enhanced teaching intervention proceeded fairly speedily in this group.

Other subjects did not gel so readily. For example, one of the topics identified by the mathematics committee was "Word Problems". The teachers on the group, when asked about topics that were perennially difficult to teach and to learn, noted that word problems are notoriously challenging. Such problems describe some situation in verbal form and ask students to solve some mathematical problem presented by the situation. They typically appear at the end of a chapter or unit on some particular mathematical operations and require students to use the concepts and algorithms presented on the preceding pages of the textbook. Teachers reported that students often had no idea what operation to use in solving word problems. They tended to rely on ritualistic ploys rather than examining the structure of the quantitative relationships presented in the problem.

The academic on this group perceived students' difficulties with word problems as a symptom of a more fundamental lack of understanding about the mathematics of particular kinds of quantities. Specifically, he identified intensive quantities as the bullseye in this target of difficulty. These quantities, sometimes called "per quantities", include ratios, rates and proportions. Their central feature is that they specify the relationship between two numbers. The academic pointed out that intensive quantities are conceptually difficult, in part because their arithmetic is counterintuitive. Suppose you have two piles of coffee beans--one

that weighs 2 pounds and cost $10 dollars, and a second that weighs 3 pounds and cost $12 dollars. If you combine the piles, you add the weights and the costs of the separate piles but you can't just add their costs PER pound.

The teachers defined the word problem problem in terms of the types of problems, taken from their texts, tests, and workbooks, that students frequently failed. The academic, called S, defined the problem in terms of an underlying mathematical concept, described with language that was unfamiliar to most of the teachers. Through his lens, S could see the problem in relation to his overall map of mathematics, recognizing this fundamental topic as part of a set of neighboring mathematical ideas.

S recalls the early conversations with teachers about the heart of the word problem problem as full of conflict. He and the teachers became "polarized" over the way they defined the important questions worth investigating. "I remember a range of emotions in myself that went all the way from rage to anger....I thought I was respecting what teachers brought to the table, and I thought what I brought to the table was going to be respected. What I brought to the table was analysis going back on the order of ten years as to the guts of the problem, building widely on what others had done." Instead, he recalls that his analysis of intensive quantities "was largely construed as abstruse and theoretical and without purpose." Remarks made by at least one of the teachers made him "feel that this formulation was too remote from the concerns and questions of the teachers, and that despite my ideological commitment to collaborative work, I damn well better find somebody else to do this because I was not temperamentally suited."

A second academic, who later became the leader of this project, experienced a similar incongruence between the conceptual framework he used to define this target of difficulty and the one teachers seemed to use. He responded by proposing that the group read and critique some papers that had shaped his views. He suggested that members of the group take turns leading discussion of the readings during part of their regular meetings. He recalled that teachers "read the stuff and began to make sense of what I was pushing, which was to get at the...cognitive foundations of what appeared to be behavioral syndromes that the teachers had a tendency to want to attack directly." He felt the group functioned for a while like a graduate seminar where participants developed a shared vocabulary and conceptual framework that enabled them to converse meaningfully as they continued their collaborative research.

B. Diagnose the roots of the target of difficulty

Having defined a topic upon which to focus, the Working Groups proceeded to clarify the reasons behind its difficulty. This might include reviews of related literature, further analysis of the subject matter to get the intellectual story line straight, review of common curricular materials to learn how the topic was typically presented in schools, and diagnosis of the ways students tended to understand and think about the topic. Researchers associated with ETC tended to believe that learning of hard concepts requires students not simply to take in new information, but to construct a new understanding by actively changing their minds. From this perspective, knowing what students already have in mind is thought to be a necessary step in designing materials and activities to help them challenge and change their ideas.

Conflicts around the merits, methods, and appropriate duration of this diagnosis of student thinking arose in several groups, but were particularly apparent in a project aptly titled Complex Systems. This group had formed at the request of one science teacher who feared that the "target of difficulty" strategy was too conservative. He wished ETC would include at least one topic thought to be too challenging for school children, which might now be made accessible by new technologies. He nominated the analysis of multivariate systems as a candidate topic. Although none of the academics originally involved in the ETC Science Committee was inclined to lead a research group on this topic, a developmental psychologist deeply devoted to the "constructivist" school of learning theory was persuaded to become the group's leader.

Like Word Problems, Complex Systems constituted a large ill-defined set of difficult ideas. Clarifying the root of the problem was a complex undertaking in itself. In keeping with her research interests and accustomed methodology, the academic, called D, proposed to conduct clinical interviews with some students to clarify their ways of thinking about systems. She wanted to engage students in active exploration of an interesting system, simple enough to be analyzable yet complex enough to puzzle children. She and her research assistant devised a system of helium balloons trailing strings long enough to cause the balloons to hover in mid-air neither rising nor falling. They proposed to use this system to clarify how students think about dynamic equilibrium, a key concept in many complex systems and an important idea in science. Tension mounted in the group as teachers who were used to knowing and telling answers confronted a researcher whose life work has been to resist this urge, in order to reveal the confusions underlying apparent knowledge and to support people's capacity to develop ideas.

D's research assistant C recalls that the conflict between teachers and researchers came to a head as she and one of the teachers on the group jointly conducted a series of clinical interviews with students from this teacher's school. According to C, the teacher, J, "didn't agree with our premise--she didn't like kids not to know the answer. She didn't want them to feel frustrated." The first time the teacher raised this concern, C dismissed it because she thought the teacher simply did not understand or value this kind of research. The second time, C realized that the teacher was "saying something about the credibility of this research for practitioners. Teachers would ignore the results of this research because it was conducted under circumstances very far from their current practice." As they argued between interviews during lunch one day, C felt each finally managed to express her views in terms the other could understand. "That was real collaboration. We each had to butt our heads."

As a result of this exchange, C responded differently to a situation that came up in the afternoon's session. A student who was frustrated by her own confusion about the balloons blurted out in exasperation, "What is the answer? Would you please just tell me?" Sensitized by J's remarks at lunch, C responded, "I need to understand your question. Then maybe I could use my words to explain to you how I understand the answer. OR then we could work together until you figure out how you understand the answer. Which would you rather do?" The student thought a moment and then said, while J continued to watch, "I want to understand the answer." C reports that J later told her she was amazed by the student's response and wondered how C had backed her into answering in this way. C regarded this incident as as a seminal collaborative experience where she finally understood how J viewed her responsibility and together they found a way of proceeding that was ethically and educationally acceptable to them both.

Despite this happy story, both this Group and others dealt with struggles between researchers eager to understand how children's minds work and teachers who felt pressed to educate those minds.

C. Design interventions and pilot test them clinically

Based on their analysis of the subject matter, the existing curriculum, and students' thinking, the groups designed experimental lessons, involving computers as well as more traditional technologies. Basic differences in priorities and assumptions were revealed when either researchers or teachers designed lessons without regularly consulting the other group. An example from the Scientific Theory and Methods Project (STAMPS) illustrates this common problem.

STAMPS focused on teaching students about the process of conducting scientific inquiry. Two teachers on the group had a running argument with the Project Leader about the feasibility of teaching middle school students simultaneously about particular content and about the process of reasoning scientifically. The teachers claimed that most students this age were not cognitively capable of attending to both matters at once. They cited Piaget's research in arguing that the students were not yet developmentally at the formal reasoning stage. Meanwhile, the Project Leader M claimed that students could understand the purpose and process of scientific reasoning only within the context of experimenting and revising their theories about some specific phenomenon. She argued that even young children build theories and, as they gather more information, they refine their concepts and revise their theories. Challenging common interpretations of Piaget's work, she believed children's development over time is more a reflection of their increased knowledge than of some fundamental shifts in the kind of reasoning they are capable of conducting.

This continuing disagreement resurfaced as the group began to design experimental lessons. The teachers offered to prepare some lessons, building on the ones used in their school system to teach about scientific methods. They knew these lessons held students' attention, and believed they served to help students understand the structure and steps of a scientific experiment. Each of the several lessons they prepared dealt with a different phenomenon: e.g. rates of absorption by paper towels of water containing different concentrations of soap, heights of different balls when bounced, and factors affecting pendulum swings.

When the Project Leader M reviewed the lessons, she found they violated her basic principle, to wit, students cannot truly appreciate the process of scientific reasoning unless they see its value in helping them develop and revise a theory about something. She firmly believed that the lessons must deal at length with one phenomenon, rather than deal more superficially with several different subjects. She therefore decided not to use the lessons developed by the teachers, but to insist that the group develop a series of lessons around a particular topic.

One of these teachers recalled this episode with distress. "We spent several summer evenings writing up these lessons, trying to use the same terminology of 'hypothesis' and all [that the other experimental units employed], and then it was never tried out. We just were not heard."

M's memories also conjure frustration. "I came close to exploding when people would lecture me about what Piaget had shown that seventh graders can and cannot do." Reflecting on the group's history, she perceived that the group had unclear goals from the outset, leaving room for different members to hold conflicting expectations.

> If we had been totally clear about what we wanted to start with, we might have been able to engage in a more collaborative way from the beginning. But as it became clear what our [the researchers'] goals were, it was hard to communicate with them [the teachers]. In the end, the way we communicated with them was to develop our own materials. When we developed our own materials, their reaction was 'that's not possible, that won't work, that's too ambitious, you can't do two things at once.'

Another ETC researcher saw the conflict in this group as a reflection of the different nature and quality of the kinds of knowledge brought by different participants to the collaborative research endeavor. "The character of knowledge that the successful practitioner-collaborator brings is empirical knowledge and the character of knowledge that the successful academic collaborator brings is analytic knowledge. In the case of [the teachers who denounced M's approach], [their] empirical knowledge was not empirical, and [their] analytic knowledge was faulty."

D. Design and conduct teaching experiments in classrooms

This conflict in the STAMPS group eventually eased as the group proceeded to try out their teaching unit with students. Some teachers in the group agreed to pilot test the materials developed by the researchers. After one cycle of pilot testing, the materials were revised and then taught by a teacher W who had not been part of the original Working Group. Without the legacy of conflict, and perhaps because she was introduced to the ideas when they were already instantiated in a classroom-ready approach, W found the underlying conceptual framework acceptable.

M and other university-based members of the group found this stage of collaborative research very valuable. They found that W was extremely knowledgeable and helpful in revising and extending the experimental lessons to make them more feasible for classroom use.

W said she also found this work satisfying, though not free of conflict. She participated in pilot testing some lessons with small groups of students after school and recommended several significant alterations to make the lessons more practical with whole classes of seventh graders. Her recommendations were based on two concerns. First, the "flow of ideas" was not sufficiently clear and, second, the lessons involved too much telling by the teacher.

> It was the mind-set of telling students what to do, rather than trying to take what the students come up with and working from there. You have to be open to take all kinds of ideas, and yet bring it together, and lead them where you want them to be...You don't just tell the student to do this...you have a discussion so that they understand what they're doing.

When she was asked a few months later to teach the revised experimental unit to her class, she found that "some of the things we had said absolutely would not work had been put back into the lessons." W felt the researchers ignored what she said until the research assistant co-taught these lessons with her. The research assistants agreed that co-teaching with the teacher, trading the roles of teacher and observer, helped them hear the teacher's voice in a new way. One research assistant said:

> Teaching the unit myself put me in a whole different position to criticize the unit...You find yourself thinking, of course this can be done. When the teachers say it's not possible you think, well, they just don't understand.... But the fact is you don't know until you do it... with the first five minutes getting the kids to sit down and the last five getting them settled before the bell rang. It was an incredibly great experience.... Having to think what you want to do and do it at the same time is not easy.

As another research assistant put it,

> I learned a lot about how to actually implement a technique we were discussing. It's often too much for too little time, or it's something you could do once, but you couldn't do it five times in a day...It's a whole elaborate procedure, trying to make connections in kids' heads. You have an idea on paper, but when you try to chunk it up into classes, the connections get lost...Watching one kid [in a clinical study] you forget how much of the problem comes from the constant distractions in a class.

Another research assistant was thoughtful about the reasons that teachers and researchers have difficulty taking each other's wisdom into account.

> I think there were times when senior researchers forgot what had been learned about some lesson. They forgot that teachers had tried out something...not everything got written up from the pilot work. Teachers were extremely offended and rightly so. They thought, "I did that a year ago and now you're going to do it again. You try it and it doesn't work. I told you that a year ago". In part it's that different people are involved and may not always have heard things. It's very hard to hear things that you don't agree with.

E. Analyze research results

Some university-based participants described tensions that arose when teachers who participated in teaching experiments collaborated in interpreting the results. Research assistants noted that teachers had valuable insights to share about their students' responses in the clinical studies, based on intimate knowledge of what a student had been previously taught and how the student typically approached such tasks. "But the trade off was that during the

discussion of the student, the teacher sometimes gave the impression that she felt she was being evaluated...One example doesn't discourage a confident, veteran teacher, but you don't want want to see a lot of these things creep into the discussion. It was sometimes awkward, but it was a trade off because if you work with other teachers' students you lose [their insight]."

The mirror image problem arose when researchers DID think that the teacher was part of the problem. One research assistant recalled working with someone whom she thought was an excellent teacher, but "She had low expectations for her students and thought half of them shouldn't be in this class. That's something we might have wanted to discuss [in analyzing the results of the teaching experiment], but we wouldn't do that with her."

Teachers who participated in analysis of results sometimes questioned researchers' methods, especially regarding the validity of clinical studies. Teachers were often amazed that researchers were prepared to draw conclusions about students in general based on observations of only a few students or classes. One project began by closely observing a few students work on problems in order to understand how they reasoned. A teacher in this group said,

> I didn't think that was a sufficient sample...I would want to chose a group of kids with a lot of differences among them in their learning styles, with different learning abilities and backgrounds in mathematics.

She also thought the clinical methodology was vulnerable to bias. In reviewing the protocol of a clinical interview conducted by one of the researchers in her group, she noted that the student had offered several responses to a question. She thought researchers had interpreted the student's response as indicating more understanding than she herself believed the student actually demonstrated.

> I know kids who know how to read your face, and when they say something, and they see a twitch, they'll change their answer. They know how to read every line on a teacher's face. I think that if you're not a teacher of kids, or if you're not aware of that, and you want to [hear] something [in the kid's answer], then you can.

The most effective way of coping with these uncomfortable differences in the interpretations of research results appeared to be the open discussions made possible by the kind of trading roles described earlier. As one research assistant put it:

> You can say that we're evaluating the curriculum, not the teacher, but one thing that really helps make that point is when you have a research assistant teaching for the teacher to observe. The teacher gets a really good view of what's happening in her class from a different perspective and she can offer a lot of insights that the

> regular observer couldn't because they don't know the kids. Also, when you have a teacher and an RA teaching the same curriculum, they can exchange information and learn from each other how to teach it. Then the teacher is not alone in receiving criticism. And then it becomes a communal effort in how are we going to make this curriculum work.

Endorsing this approach, another research assistant said, "When you teach and then the teacher teaches...you are equal sharers. Each of us was open, we traded ideas, then the teacher was able to step back and think about the theory." Tensions were more likely to remain undiscussed and unresolved if participants had not made this kind of effort to view the work from the others' point of view.

F. Report research results

Further differences in perspectives of teachers and university people were apparent in their reactions to reports of research results. For a variety of reasons, including the much greater time commitment of university-based participants, academics rather than teachers wrote most research reports. To respect the collaborative spirit of the work, Project Leaders were urged to circulate drafts of reports among members of their group and take their comments into account before submitting final drafts.

Project Leaders reported that they rarely received any feedback from teachers in return for the significant nuisance of distributing copies of the draft report as publication deadlines loomed. Teachers noted that they had several reactions when faced with these technical reports. First, they were often written in obscure jargon that was sometimes as difficult to interpret as a foreign language. One consequence was that teachers required hours to wade through the reports. By the time they were able to devote this much time to the endeavor, the publication deadline had often passed. Second, the reports often treated topics at length that had little meaning for teachers, while ignoring the teachers' experience and the implications of the research for teacher's work. One teacher was particularly disappointed to read pages of "verbiage" which in his view simply attempted to explain away the fact that the experiment had failed. As a teacher, he knows when a lesson does not work, and regularly has to revise and try again. His perception was that researchers are not willing simply to admit failure and move along.

Another source of tension around research reports concerned the different purposes that people expected a document to serve. One clear example emerged from the work of the ETC Laboratory Sites Project. This project was initiated in the fourth year of the Center's life to

study how ETC-developed innovations might be carried out in regular school classrooms. Teachers from five different secondary schools were recruited, trained, supported, and studied to learn about the processes and requirements of incorporating these innovations into classroom practice.

An illuminating conflict arose around teachers' reactions to an interim report on the process of teaching the unit developed by ETC's Heat and Temperature group. This research group's lessons involved fairly complicated apparatus including computers with peripheral devices, as well as more traditional "wet lab" equipment such as beakers, graduated cylinders, hot plates, water, and ice. Lab site teachers working with this innovation found they must design additional lessons tc weave the experimental unit into their regular courses. These teachers also provided vivid, detailed accounts of the many kinds of prerequisite skill and knowledge that students needed in order to benefit from the research group's lessons. Students had to be able to keep track of materials and ideas from one class to the next during the unit; they had to be able to set up and operate complex fragile apparatus and know how to cope when it broke as it often did; they had to be able to divide up tasks among the members of the small groups who worked together at each lab station; they had to understand the overall structure of the experiment well enough to know when and how to make and record critical observations. These significant requirements had not been revealed during the previous field tests, involving only a few students or hand-picked, carefully supported classroom settings.

The problem arose in reporting on these valuable insights. After reading the draft report, science teachers in the laboratory sites were quick to acknowledge the accuracy of the classroom picture: equipment malfunctioning, students not realizing when to watch the computer monitor for critical real-time data, one student in a trio missing half the experiment by going to the bathroom while his partners continued. But some did not want these images included in the case study. "I'd hate for my superintendent to read this," said one teacher. "I'm sure he'd blame us teachers for not having better control of the class." What the Project Leader regarded as a powerful revelation of the gaps between clinical research and classroom life, the teacher regarded as an indictment of her colleagues' professional competence.

IV. THEMES AND CULTURAL DIFFERENCES

Several themes emerge from this set of vignettes about collaborative research that reveal differences in the culture of schools and universities. The following discussion focuses on a few of them, not attempting to be comprehensive, but hoping to stimulate further thought about this topic.

A. Maps of the subject matter domain

Academics tend to focus on key concepts in a discipline. They tend to see them as part of a web of related ideas forming the conceptual foundation for theory building within a domain. They perceive multiple ways of approaching such concepts from various related ideas that form part of the theoretical web.

Teachers' views of the subject matter--at least when they think about teaching it to students--tend to be informed primarily by the structure of their text books, work books, and curriculum guides. One feature of text books is that they typically focus on a much smaller grain size of information than the "big ideas" in terms of which academics map the intellectual terrain. Intensive quantity, for example, is nowhere mentioned in the typical mathematics textbook, although the concept appears in multiple guises under the headings of multiplication, division, rates, proportions, ratios. These topics in the textbook are further subdivided into short and long division, multiplying with single digits versus two or three digits, and so on. As these topics appear in quite different places in the text, and across different grade levels, their common underlying conceptual basis that the academic perceives may not be at all apparent to the teacher.

A similar sort of distinction about the grain size of ideas became clear as teachers and researchers discussed the process of mathematical or scientific reasoning. Teachers were accustomed to teaching students definitions of terms like dependent variable, independent variable, hypothesis, and conclusion as distinct elements in a generic process of scientific reasoning. The researcher worried that learning the separate elements in this way amounted to a meaningless ritual unless their relationships and value became apparent in developing, testing, and revising a theory about some particular data.

Besides chunking knowledge into smaller disconnected bits than university-based scholars often prefer, text books also present subject matter as a linear sequence of topics. Teachers often teach topics in the same order as they appear in their textbooks, and may believe that this order reflects the best sequence for building students' understanding. If they commonly map the subject in this linear way, they may not recognize the multiple relationships that connect ideas in the academic's web and the multiple paths that can be used to relate students' notions to the teachers' curricular agenda (Lampert, 1988).

Unless academics and teachers can describe their maps to each other and explain how they use them to guide their work, both are likely to misunderstand and devalue the other's framework. Discordant maps and vocabulary, leading people to use the same word to mean

different things, may cause the apparent consensus researchers and teachers achieve in defining a research focus to deteriorate as they proceed to work on the problem (Wagner, 1986). In order to conduct collaborative research that makes sense in both worlds, they must define a shared vocabulary and recognize some correspondence between elements and relationships of their different maps of the subject matter.

B. Nature of research

The Educational Technology Center's mission, to conduct research on ways of improving education, encompassed a range of goals spanning the middle of a continuum. At one end of this continuum lies basic research, whose purpose is the production of knowledge without concern for its practical application. At the other end lies educational practice not based on any theoretical foundation. In between lie a range of other activities. These might include research into children's cognitive development as a foundation for designing an educational intervention or theory-based design and experimental use of lessons in regular school classes. Understandably, ETC researchers and teachers tended to have different priorities. Lawrence Stenhouse helps clarify their priorities by distinguishing between "research acts" undertaken to "find something out" and "substantive acts" which are "justified by some change in the world " (Rudduck & Hopkinds, pp. 56-57). Some ETC researchers were content to build cognitive theories without pressing on to develop educational interventions. Some teachers became impatient with years of preparatory research which produced neither materials nor strategies that could be used in normal classrooms.

Features of the research/practice tension, the "paradigmatic pinch" that McDonald (1986) and others (Barzun & Graff, 1977; Eisner, 1985a; Popkewitz, 1980; Sirotnik, 1988) interpret as reflecting different underlying epistemologies, can be discerned in the story about the helium balloons. The choice of helium balloons, selected by the researchers because they were engaging and illustrated dynamic equilibrium, was denounced by some teachers because the balloons would be so impractical in the classroom. The teacher regarded the clinical interview as an educational experience for the student. She wanted the child to be treated as the teacher would have treated her in class, not allowed to feel stupid nor discouraged by a prolonged period of ignorance unlike anything the teacher would willingly sustain in class. While the researcher studied how students learn, the teacher was worried about how teachers teach. Some teachers recognized that research activities might not lead directly to classroom-ready approaches, but most were reluctant to postpone asking, "How will this work in a school classroom?"

Assumptions about the purpose of research help explain the science teacher's discomfort with the case study. She interpreted the case primarily in personal terms of its effect on her colleagues within her particular school setting. Eisner (1985b) notes that practitioner accounts tend to treat "individual agency" as a central ingredient, a tendency that tugs against the "impersonal" conventions of researchers reaching for generalizable findings. To the extent that the teacher considered the report's more general implications, she assessed its probable effects on people working in schools. The researcher interpreted the same case primarily in terms of its capacity to illuminate important features of classroom life for researchers. Each had a different audience in mind, and their assumptions about the value of research reflected their expectations about how those audiences would interpret and act upon the research results (Erickson,1986).

Teachers' focus on local interpretation and practical application in schools helps explain, too, some of their discomfort with clinical research results. Their responsibility is to educate groups of 20-30 students usually in the context of 45 minute periods packed tightly into a 6-8 hour teaching day. Living in this environment, they are rightly wary of the findings from closely watching one or a few students in quiet little corners away from the many distractions of classroom life. They are challenged to respond to many different kinds of students with a range of intellectual styles, levels of knowledge, and ways of relating socially and emotionally. Teaching a few students under ideal circumstances does not necessarily reveal anything that will work with most students in classroom situations. Competency indicated by a post-test at the end of a teaching experiment or even a month or two later does not necessarily constitute mastery of the sort a teacher seeks. The proof of the research pudding for teachers is quite remote from the results that many researchers find sufficiently satisfying.

C. Nature of knowledge, teaching, and learning

For most academics, especially those based in major research universities, knowledge is less a product than a process of on-going study and communication. Most see themselves as knowledge makers who continue their own study and stay abreast of developments in their field. Their responsibility to their students includes an obligation to help their students learn how to be knowledge makers, cultivating in them the taste and capacity to invent, critique, and synthesize powerful ideas. Thus the distinction between teachers and learners blurs in higher education.

Many school teachers share these ideas, but most work in settings that emphasize their obligations to transmit knowledge to their students rather than construct and critique

knowledge with their students (Cohen, 1988). School teachers feel obligated to "cover curriculum requirements". They are responsible to students to prepare them for the standardized tests they must take before they can pass on to the next grade. This requirement is especially potent in secondary school where the tests can open or block entry into college. Principals, department chairpeople, and parents may pressure teachers to assign materials from particular texts and exercise books, these "treaties" (Powell et al., 1985) that legitimate what is to be taught. Under these circumstances, knowledge takes on a more determined, fixed, and sacred character. Gaps open between those who make knowledge, those who transmit knowledge, and those who absorb knowledge. University scholars may belong to the first group, school teachers to the second, and school students to the third.

Interestingly, school teachers--so often portrayed by researchers as locked into a "transmission" rather than a "constructivist" pedagogy--may be more alert to the dangers of teacher talk than academics. More than one teacher involved in ETC research projects complained that the lessons prepared by academics call for teachers to present too much information didactically.

So long as different assumptions about the nature of knowledge, of teaching, and of learning remain tacit, researchers and school teachers can easily misunderstand each other. They may assume a shared perspective, each using the same words to mean different things, and becoming increasingly frustrated as they talk past each other. Without clarifying their assumptions about educational agendas and pedagogical philosophies, the stage is set for confusion and frustration. Without understanding the structures and incentives of schools and universities, neither group is likely to understand or value the others' frame of mind.

D. Time

Differences in perceptions of time in schools versus universities appeared throughout this project. Scheduling meetings of the collaborative groups created tensions. University people scheduled the first meetings during the school day, knowing that substitute teacher coverage had been promised and thinking that would inconvenience teachers less than after-school meetings. But teachers objected, saying that preparing for and cleaning up after an ineffectual substitute meant a one-day meeting took three days of their time. They preferred to meet after school.

Teachers noted that researchers had much more time available to invest in the project. First, researchers were paid to devote 15-25% of a full-time equivalent to the project while teachers were expected to fit 1-2 days of time per month around their full-time commitments at

school. Second, teachers perceived that researchers had much more control over their time at the university, than teachers whose entire school day was tightly packed into a completely structured time grid.

The month-to-month calendars for schools and universities are also mismatched enough to create significant inconvenience in planning joint activities. The beginning and ending of terms, vacations, and examination periods make for incongruence in convenient times for teaching experiments.

Finally, researchers had a different perspective on the pace at which a project was expected to proceed. As Barzun and Graff (1977, p. 5) note, "School people are very firmly rooted in the present. Their focus is, of necessity, on currently available answers to immediate problems." Teachers connect with their students for usually no more than one year. If they do not succeed in educating the student during that time period, their opportunity is lost. While professors may face a similar constraint in their classes, they normally expect their research to require a period of years to bear fruit. Thus "projects which appear to be proceeding in a timely fashion for one group may well be experienced by the other as entirely out of synchronization and consequently counter-productive" (Gifford & Gabelko, 1987, p. 383).

E. Ownership and responsibility

Like the research assistants quoted earlier, teachers who participated in ETC research projects found the work most satisfying when researchers became part of their world at school. "I found that [the work] became much more interesting when we could focus on some concrete experiences and discuss our perceptions of them rather than just talk about theoretical stuff." Teachers thought that researchers would understand better what teachers were saying at meetings if the researchers had spent a little time in the classroom. "I think a day in the classroom would do it," suggested one teacher. "They're so much smarter in their field, and we're so much smarter in our field. We know kids and we know classrooms and we know a lot of the reality they don't know. They know theory that I could live twice and not understand. Somewhere along the way we have to bring that out and respect each other for the strengths that we both bring."

In response to this suggestion, another teacher replied, "I don't perceive it as one group being smarter than the other--I think it's who's controlling the game, who is going to have the last say, and who is going to be listened to. You know that if [school people] were running this game, the reports would have looked different, the meetings would have looked different, the

activities and time lines would have looked different. The people who have charge of the money hold the cards that dictate the game."

In the collaborative research project examined here, the prime contractor was indeed the university, the various projects were led by university scholars, and the project sponsor expected the resulting work to meet the standards set by university-based researchers. Under these circumstances, the university-based participants may be "more equal" than the school-based members. While most ETC participants recognized that the academics made a good faith effort to collaborate, school people found that the university people's worldview tended to predominate in the design, conduct, and interpretation of the research. McDonald (1986, p. 131) pointed out that because ETC's work was very much the work of the university--knowledge expansion--it included "the inevitable tension involved in maintaining a full partnership on one partner's terms."

In essence, teachers want some assurance that even if researchers do not espouse the same goals as teachers, at least they will hear teachers' voices and respect their concerns. If teachers are to help researchers address their agendas, they want to know that the researchers will reciprocate by sustaining their connection with the project until it produces results that address the teachers' agenda.

Researchers voiced parallel concerns. They explained that the teachers on their group sometimes acted like a Board of Directors, with the power to veto any ideas but no responsibility for moving the work along. Many researchers came to value the contributions that teachers could make, but resented objections unaccompanied by constructive assistance.

V. RECOMMENDATIONS

A. Sustained commitment

Upon reflection, nearly all participants in ETC research realized that teachers' contributions were often severely limited by the small amount of time they were able to devote to the work. If teachers are to be full partners in collaborative research projects they must be involved for as much time as the other actors. This might involve an on-going arrangement of 25% or more time, accomplished by buying a secondary school teacher out of several courses. The structure of elementary schools makes this arrangement difficult. For these teachers, a leave of absence and summer work might be arranged to free a teacher full-time during a

critical period of the research. A less intense involvement could sustain commitment between these periods of full-time engagement.

Continuous involvement of both school-based and university-based participants throughout the various phases of this kind of research is another boon to effective collaboration. Over time members can define a shared vocabulary, clarify disagreements, trade favors, learn to fight productively, and develop loyalty to their shared work. All of these steps are necessary for members to learn how to make their expertise useful to an endeavor that only partially coincides with their individually-held goals.

B. Reciprocal exchanges

ETC's experience confirms other reports (Gifford & Gabelko, 1987; Clark, 1988) of successful collaboration which emphasize the importance of engaging participants in mutually beneficial exchanges. People are both altruistic and selfish. Their commitment to a relationship grows if they both contribute and receive something of value in the course of their participation. The focus must be on activities not the machinery of collaboration (Maeroff, 1983).

Mutual respect and understanding grew among members of ETC Working Groups as all participants contributed to getting the work done. Once the work of ETC projects progressed to the point of developing materials and strategies for classroom use, the teachers' knowledge and expertise became especially obvious and valuable. At that point researchers clearly gained from a relationship which some might have previously regarded as more trouble than it was worth to their personal agendas.

Collaborative research could be structured to ensure reciprocal exchanges throughout the process. For instance, teachers' expertise could be tapped from the beginning stages of defining targets of difficulty and diagnosing their roots. Teachers are in a good position to map the ways schools normally teach about the selected "target of difficulty" by analyzing commonly used textbooks, local and state curriculum requirements, and standardized tests. Teachers might also review alternative instructional approaches by examining the guidelines issued by professional organizations and collecting materials from other research and development efforts that had enjoyed wide-spread use in schools.

As the comments of several ETC research assistants make clear, teachers can also play a valuable part in conducting research with students. Here, their familiarity with the way students respond in school settings as well as the knowledge they may have of particular subjects' characteristics can make them valuable partners in interpreting findings.

The teachers' assistance in designing experimental lessons and research materials was frequently the most apparent and valuable contribution to many researchers. Yet the anecdotes from ETC's experience indicate that teachers' suggestions on this count may be actively discounted or passively ignored unless researchers are primed to hear the teacher's voice.

C. Mutual Education

Satisfactory reciprocal exchange clearly requires that each party develop an appreciation of the other's contribution. Reporting on their own experience with collaborative research, Gifford and Gabelko (1987, p. 382) attest to the primary "power of overcoming the we/they thinking that usually separates university researchers and school-site practitioners" based on "trust built evenly over time...that has to lap over into implementation of findings". In relationships between university researchers and school teachers, a history of mutual disrespect must be overcome. This process entails explicit education by both university and school people regarding their own cultures, to wit, the values, assumptions, and structures of their organization settings that constrain and reward their activities. Wagner (1988) calls this process "interpretive consultation" through which university researchers teach school practitioners about research findings while the latter teacher researchers about the nature and problems of practice. He believes that links between research and practice can be substantially improved through such discourse, especially when it is augmented by teacher-to-teacher exchanges.

The merits of explicit education of this sort were indicated by several examples from ETC Working Groups. When the Project Leader of the Word Problems group shared readings that informed his conceptual framework, other members of the group were able to join him in further refining and applying this framework to their shared work. When a researcher and teacher sat together long enough to explain to each other their expectations about an appropriate way to conduct a clinical interview, they were able to invent a way of proceeding that made sense to both of them. When researchers traded roles of teacher and observer with collaborating teachers, their eyes were opened to insights previously inaccessible to them.

Several features of most school-university collaborations make this mutual education endeavor a rather lop-sided one. First, there is a basic status differential between faculty members from prestigious universities and teachers from school systems which gives preferential weight to the former's views (Gross, 1988; Trubowitz, 1984). Second, university professors are rewarded in their own institution for articulating their views verbally and in writing. In contrast, school teachers are rewarded for teaching students, not for learning to

articulate their wisdom either verbally or in print. Consequently academics are more likely to be personally skillful at arguing their position, and they are much more likely than teachers to find support for their views in the literature. Finally, as it was structured, the Educational Technology Center was more nearly in the university camp than the school's. Its mission, financial structure, and physical location made this clear. Under such circumstances, the academic members of the collaborative project must make themselves particularly receptive to being educated.

Learning to hear the teacher's voice is a crucial aspect of the researcher's responsibility in collaborative research. Teachers and those researcl. assistants who ventured into the classroom world believed that a good way to cultivate this receptivity was for researchers to spend some time in the school world. In this way, teachers and researchers blended the roles of "participant observer" and "observant participant" (Florio & Walsh, 1978). As, Wagner (1988) points out, first-hand experience in the classroom sensitizes the academic to features of this setting that are difficult to grasp from second-hand accounts. McDonald (1986) emphasizes the paradigmatic obstacles impeding researchers' efforts to hear teachers' voices; "that is certain habits of thinking, believing, and working can handicap the effort to attend" (p. 46). He recommends that school-university collaborative projects make use of interpreters specifically assigned to tune in to the teacher's voice as "message rather than noise" (p. 32). These interpreters must be sensitive to both teachers' and researchers' views and skilled at helping them make sense of each others' ideas.

D. Rewards for collaboration

The recommendations so far have addressed the conditions that might promote effective communication between school-based and university-based participants in collaborative educational research. Yet individual actors cannot be expected to sustain such demanding efforts unless their home institutions reward them. Most teachers and professors work under circumstances that discourage them from collaborating. Teachers are rewarded for teaching their students the required curriculum and participating in extra-curricular activities required by their district. Few are rewarded for taking time to reflect, experiment, and inquire. Professors are rewarded for conducting research and presenting results for their own professional group, which does not usually include school people. In most university settings applied research, teacher education, and work in schools are not so highly regarded as scholarly work unfettered by such practical concerns. Until the demands of collaborative research are

understood and the products are valued in both settings, teachers and researchers willing to undertake this important work will be rare.

Building support for collaborative research requires commitment from administrative leaders, attention to evaluation and reward systems, and backing from funding agencies. Academics who extend their research beyond the ivory tower must be appreciated by their administrators, supported by funding agencies, and endorsed by professional colleagues. Teachers who strive to develop and carry out instructional innovations must be rewarded, not constrained by testing practices geared solely to the traditional curriculum. They must be given time and recognition for devoting themselves to professional renewal. Changing organizational values and structures to reward collaborative research is a gradual process, as is all education, but it is necessary to link schools and universities in their joint effort to sustain the culture of inquiry.

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